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KidBus.Tracker: The Development of a Schoolchildren Identification and Transportation Tracking System

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***Abstract*—There are approximately five million Malaysian children commuting to school every day. Approximately 40 percent of these schoolchildren rely on public and private school transportation. There have been cases that of children kidnapping reported in the news in recent years. The news on these cases is amplified further in social media and has caused concerns to parents. Nonetheless, some parents do not have an option in sending their children to school. Busy schedule and hectic working lives are key factors in the parent's decision to use public or private school transportation services. The use of these services exposes schoolchildren to risks such as kidnapping and accidents. Parents, on the other hand, could not monitor the safety of their children in commuting to and from school. This paper presents a system called KidBus.Tracker that monitors schoolchildren's commute to school. The system was developed using global positioning satellite (GPS) tracking as a way to track the school vehicle, while passive radio frequency identification (RFID) technology was used to record the children's presence on the vehicle. The data log captured from the hardware would then be extracted and processed by the server. Parents would be able to monitor the school vehicle's movement while their children are on board the school transport through the KidBus.Tracker website. The findings of the user acceptance test indicate that KidBus.Tracker can give parents ease of mind when their children are commuting to and from school using school transportation services**

Keywords — Schoolchildren safety, School transportation, Tracking System, RFID,

I. INTRODUCTION

The World Bank 2014 Education Statistics estimates that over 5,000,000 Malaysian children went to school in the year 2014 alone [1]. A study in 2006 reported that 37.5 percent and 40.3 percent of students surveyed commuting to and from school using school public transportation daily [2]. The Minister in the Prime Minister Department Datuk Nancy Shukri stated that an estimated 1.5 million schoolchildren used registered school buses in 2016 [3]. With a significant portion of the population commuting via school public transportation, there is bound to be a risk of transportation hazard faced by the schoolchildren. Safety and security is one of the factors that influence parents in determining their choice of pre-schools education in Malaysia. Schools with security features such as CCTV and provides transport is a preferred choice for working parents and for many parents living in rural or semi-rural areas [4]. [5] stated that public or private school transport is the transport of choice among parents as conflicting time schedule makes it difficult for parents to send their children to school.

Nonetheless, schoolchildren travelling to and from school on public or private transport expose them to risks such as accidents and kidnapping. A study on the school transport accidents of reported that between the year 2003 and 2012, there were 46 accidents involving school buses where 22 of the 46 cases were fatal, 6 were serious accidents and 18 were minor accidents [6]. Thus, within this 10-year period, an average of 2.2 fatal school bus accidents happened every year.

Schoolchildren are also exposed to the risk of kidnapping as they travel to and from school. In the Dewan Rakyat, Malaysia's Deputy Home Minister stated that a total of 3,937 children, aged between 6 to 18 years old, have been reported missing between 2014 until January 2016 [7], and the media has given extensive coverage on such cases. This intensifies the negative perception on the safety of school transportation. Furthermore, at times, some stories on kidnapping have been spread in social and mass media. For instance, in 2015, a story about kidnapping attempts using school busses went viral and it spread on social networking sites [8]. Moreover, in 2017 news report, three students were nearly abducted when three unidentified men in a pick-up truck with tinted windows waited for them at the entrance of a school in Labuan. The men offered sweets but were rejected by the students. The men left after a security guard approach the pick-up truck (Malaysian Digest). This has prompted the President of the Malaysian School Bus Association (PPBSM), Amali Munif Rahmat to advise parents to be constantly vigilant. Despite the worries, some parents do not have any other choices and must rely on the available school transportation to get their children to and from school [9].

With the risks associated with schoolchildren's commute to and from school, there is a need for a solution that allows parents to track and monitor the travelling of their children to and from school on a school bus. Thus, the objective of the study is to design and develop a system called KidBus.Tracker that integrates vehicle tracking and schoolchildren identification system that can be installed in school transport vehicles. KidBus.Tracker uses the global positioning system (GPS) and radio frequency identification (RFID) technologies to identify the children and track the journey of the school bus to and from school in Malaysian context. The KidBus.Tracker allows parents to know the time their children board and alight the bus and tracks the movement of the bus through a website. The intention of KidBus.Tracker is to lessen parent's worry on the safety of their children's journey to school.

II. SCHOOL BUS SAFETY INITIATIVES

In Malaysia, school bus is a popular mode of transport for schoolchildren despite the increase of cost of living and fuel price [5]. There are two types of school transport vehicles in Malaysia; the first type is M2. This type of vehicle could accommodate less than 8 passengers with mass not exceed 5 tons. The second type is M3. This type of vehicle could carry more than 8 passengers with mass exceed 5 tons. Both types of vehicles used for schoolchildren transportation must operate with legal licensing with Land Public Transport Commission (SPAD). Solah et al 2015 further presented that statistics showed that until first quarter of 2015, 16,184 school buses were operating legally. 44% of these buses have been operational for more than 21 years old.

To ensure the safety of schoolchildren while they commute to and from school, some governments have called for efforts to install technology on school buses. In Myanmar, Chief Minister of the Yangon Region Government met with headmasters, headmistresses and school council members from 26 basic schools that use school buses most frequently. The Chief Minister put forward in the meeting that school bus services should be of international standards. The Yangon Region government has ordered 200 school buses from Korea that are equipped with CCTV and GPS [10]. In India, the Central Board of Secondary Education (CBSE) has issued guidelines to enhance safety in school busses. These guidelines require the bus to be equipped with an experienced driver, a security guard, first-aid kits and drinking water, CCTV and GPS devices [11].

The Abu Dhabi Education Council (ADEC) and Emirates Transport have initiated a project to enhance safety in school buses. The project includes GPS tracking systems to locate the bus and NFC technology on students' cards to identify the schoolchildren. Parents can track their children's commute to and from school using a mobile app and receive notifications about the bus trips [12]. In Malaysia, SPAD has instructed express and stage bus operators to install GPS in its fleet [13]. However, this does not include school busses. GPS Telematics Malaysia, a subsidiary company of IntelliTrac Australia, has a GPS tracking and telematics solutions for school buses. The solution includes school bus monitoring, student identification and monitoring of children boarding and alighting the bus. Using 2G and 3G network, the monitoring can be done in real time. Other features include video recording, image capturing, messaging and navigation [14]. Nonetheless, the cost and product acceptance from schools and bus operators remain unclear.

Some schools in Malaysia, however, provide their own transportation to pick up students from their homes to school. Nexus International School in Putrajaya, Malaysia is an example of such schools. The school outsource its transportation services to a travel agency. Parents must register to use this service and pay the fees monthly. The fees range from RM1100 to RM2500 per month depending on whether it is a one-way or a two-way trip. The bus driver will pick up the students at a pick-up point and drop off the students at school. The travel agency's bus fleet is equipped with GPS tracking system and parents can track the location of the bus through a device [15].

III. PREVIOUS WORK

School transportation tracking systems with GPS technology have been implemented in certain schools in India and the United States. In 2014, Fleetmatics Group PLC [16], a bus tracking company based in the US, conducted a survey on the need of a GPS tracker in school buses. The results of the survey indicated that 85 percent of parents agreed GPS tracking enhance the safety of school bus and the timeliness of the bus service. School bus tracking makes the schoolchildren safety more visible and the bus operators more accountable. In Denver, students in the public schools, use a system that require the student to scan their RFID cards when boarding and alighting school buses. A system logs information when a student tag their RFID while getting on and off the busses, then sends the information to a computer system which parents will be able to monitor [17]. Some schools in Massachusetts and California are also use similar school bus tracking systems.

In India, [18] and [19] developed a vehicle tracking prototype that identifies and tracks schoolchildren using RFID.

The system uses RFID to identify the schoolchildren and a GPS system that sends coordinates to the parents via SMS upon request. The system is also equipped with a vibration sensor to detect whether the bus has hit an object which signifies the occurrence of an accident. Nonetheless, SMS message is the only form of communication between the system and the parent. Similar system was developed by authors [20] that uses RFID and GSM to inform parents about their children when commuting to school. The RFID tag identifies the schoolchildren and the reader sends data such as the date and time of boarding and alighting to a server via GSM network. The system is also equipped with an LCD screen that displays the name of the students who are boarding and alighting the vehicle. However, the authors did not propose the use of any mechanism to monitor and track the route that the vehicle has taken to reach its destination.

[21] used similar technologies to monitor and track schoolchildren's commute to school. An RFID tag is used to store information about the schoolchildren and the school bus that they board to school. The information that is uploaded into the database contains the number plate of bus, driver name, conductor name, location, time and child's details. Parents is notified through SMS and can get access to the information via a website. [22] proposed a different technology to monitor and track schoolchildren's commute to school. Instead of adopting RFID, the authors proposed Bluetooth low energy device that scans, connects and reads tags worn by the children. A unit installed in the bus sends a notification message with relevant information to the parents. Nonetheless, since the work is still in the proposal stage, the tracking and monitoring mechanism of the school children is still unclear.

[23] presented a system that monitors school children's commute to school using RFID tags as the medium to track and identify school children. Two main units were proposed. The bus unit scans the children's RFID tag and the information will be sent to the school unit device and alert the parents. The system also includes a website that allows authorized personnel such as schools and parents to manage and retrieve information about their children pickup and drop-off. The authors' system, however, does not include GPS to track the journey of the vehicle.

There are two observations that can be seen from the previous works. First, most of the previous works in this section comes from India. Researchers from India seemed motivated to do such project because the death of school children due traffic accidents has become a national concern. The World Health Organization (WHO) statistics in 2010 reported that 41% of deaths of children in India are due to the lack of road transportation safety, a figure that is the highest in the world [24, hence, Parents in India are worried about sending their children to school. Second, nearly all of the related work involves the use of RFID technology to identify and track school children. The information is captured are the date and time of boarding and alighting. Some of these works have equipped their monitoring and tracking system with GPS. The GPS technology is used to track the school vehicle. All of the notification to the authorized personnel are sent via SMS via GSM network. SMS, on the other hand, is known for its limitation not only from a technical perspective but also its contents; SMS has some disadvantages from a technical point of view. First, SMS are costly and second, SMS is not able to provide rich information to the user as it only supports text-only messages and it has a 160 characters limitation. Thus, SMS technologies can only be used to provide byte-size content or interaction. With this limitation, the use of SMS text messages can be very limiting for an alert system.

IV. METHODOLOGY

The methodology of this study involves of two main phases namely Phase 1: Preliminary study and Phase 2: Kidbus Tracker system development. Figure 1 shows the methodology of the study

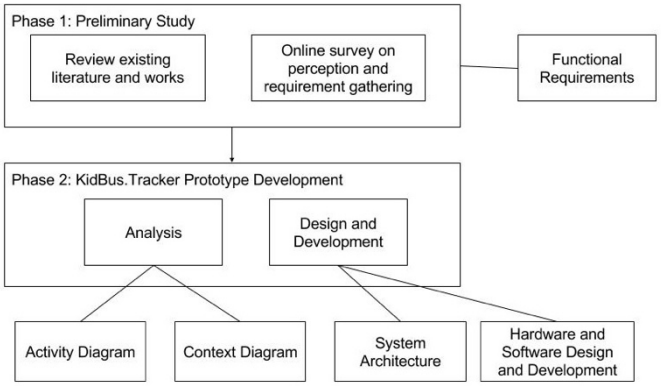

Fig. 1. KidBus.Tracker Development Methodology

In Phase 1: Preliminary study phase, existing literature and technologies in other countries were reviewed. In addition, an online survey was distributed to parents who send their children to school using public or private transportation to identify user requirements. Thus, the user requirements for KidBus.Tracker were obtained through data collected from preliminary study and from reviewing existing literature and technologies. The output of this phase is a list of functional requirements.

The system development methodology used in this study is based on the system development life cycle model. As depicted in Figure 1, Phase 2: KidBus.Tracker Prototype Development consists of two major sub phases, which are analysis and design. For the analysis, the user requirements gathered from Phase 1 were transformed into an activity diagram and a context diagram. The design phase includes the development of the hardware and application; hardware design includes the design and development of the GPS and RFID hardware. For the GPS, the hardware includes Arduino Mega ATmega1280 as microcontroller and SKM53 GPS Shield as a GPS device. The RFID devices include Wiegand RFID Reader, RFID cards and real-time clock module. The application design focuses on the design and development of architectural, business logic, database and user interfaces of KidBus.Tracker. The KidBus.Tracker website provides the visualizations of the journey of a child on a school vehicle at any given time. With the website, parents can monitor and track their children when commuting to and from school.

V. PRELIMINARY STUDY RESULTS

In Phase 1, an online survey was distributed to parents to not only gather requirements but also to gather parent's perception towards school transportation and the feasibility of a system to identify schoolchildren and track school vehicles. The survey was distributed through several school's Parent Teacher Association (PTA) Facebook pages and parental groups. The survey has three parts, the first of which is to gather the general and demographic information about the parents, the second is to gather parent's perception towards school public transportation, and finally to measure parent's interest in using an application to track their children's commute to school. The second and third part of the survey uses the five-point scale as a unit of measure. Only seventeen participants responded to this survey.

The results of the survey indicate that 76.4% of participants agree that the school vehicle operators provide reliable service and the school vehicle drivers are competent. However, 41.1% of the participants feel that some vehicle operators neglect safety procedures when driving the schoolchildren to school; in this regard, 59.8% of the participants feel that the school vehicles sometimes carry more passengers than the maximum capacity. Nonetheless, 52.9% of the participants are confident that their children are safe during their commute to school but 58.8% of the participants are still concerned about their children's commute to and from school. The parent's concern is amplified when majority of the parents have no information about the status of their children whether they have board or alight the bus. Not only that, 64.7% of the participants have no information about the school vehicle's current location at any given time during the children's commute. The results of the preliminary study solidify the need of a system such as KidBus.Tracker that could inform parents about the where about of the vehicle that is carrying their children to and from school. From the survey, the functional and non-functional requirements of KidBus.Tracker was obtained. The requirements of KidBus.Tracker is as follows:

- The system can send notifications to parents when their children board or alight the vehicle.
- The administrator of the system can register the schoolchildren.
- Users (i.e parents) can view the bus location on a map and determine whether their children have boarded or alighted the school transport vehicle.

VI. KIDBUS.TRACKER PROTOTYPE DEVELOPMENT

This section presents the prototype development of KidBus.Tracker. KidBus.Tracker's context diagram and analysis diagram are the results of the requirement analysis and the prototype design includes the hardware and software design.

A. KidBus.Tracker Context Diagram

Figure 2 shows the context diagram of KidBus.Tracker. The RFID enables the identification of the children by KidBus.Tracker system.

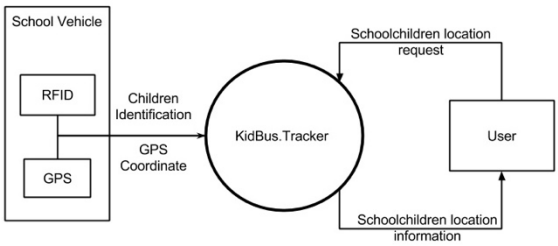

Fig. 2. KidBus.Tracker Context Diagram

The system development methodology used in this project development is based on the system development life cycle model. It consists of three main phases which are planning, analysis and design. The design phase includes the development of the hardware and software. The hardware design includes the design and development of the GPS and RFID hardware. For the GPS, the hardware includes Arduino Mega ATmega1280 as microcontroller and SKM53 GPS Shield as GPS device. The RFID devices include Wiegand RFID Reader, RFID cards and real-time clock module. The software design focuses on the design and development of KidBus.Tracker website.

B. KidBus.Tracker Activity Diagram

There are two activity diagrams developed for the system. The first activity diagram involves the events for the schoolchildren. Figure 3 shows the KidBus.Tracker activity diagram for the schoolchildren.

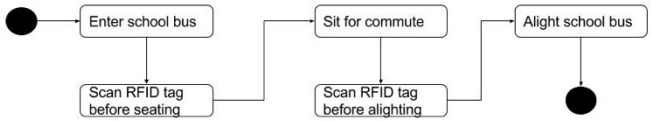

Fig. 3. KidBus.Tracker Actvity Diagram for Schoolchildren

Parents are required to register their schoolchildren with the school bus operator. The school bus operator will then assign a vehicle and a bus driver to the registered school children. Each registered child will receive an RFID tag. The RFID tag contains information such as each child's name, address, contact number, vehicle plate number and driver. Before boarding the school bus, the schoolchildren would need to place their RFID tag close to the RFID reader. This would record the children's name boarding time. The data is send then transmitted to a cloud server. The same process is repeated when the schoolchildren is alighting the school bus. Figure 4 shows the activity diagram for the parents.

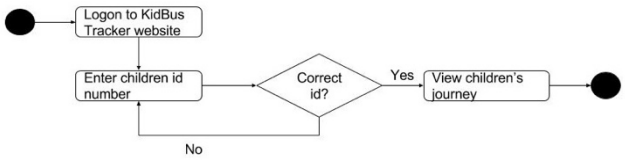

Fig. 4. KidBus.Tracker Actvity Diagram for Parents

The parents can track the journey of the school bus and obtain other information by accessing the KidBus.Tracker website.

C. KidBus.Tracker Prototype Design

Figure 5 shows the architecture of KidBus.Tracker. The architecture consists of four main components. The first component is the GPS device. The GPS device tracks the movement of the school vehicle by sending signals to the GPS satellite. The second component is the RFID system. This RFID system is a passive system which contains the reader and the tag. The RFID system identifies the children who are boarding and alighting the vehicle. Both RFID readers and GPS devices are fitted into the school vehicle. The data collected from these devices will be stored as data log.

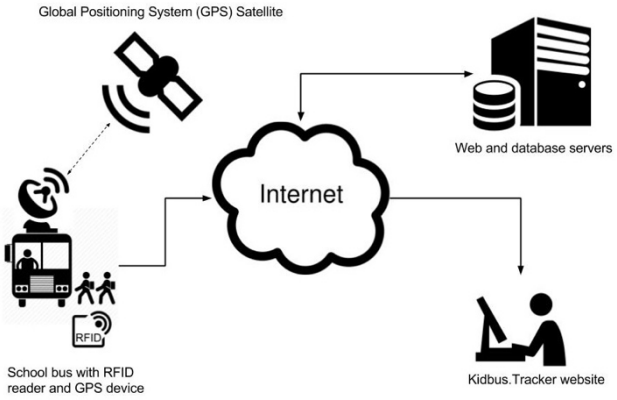

Fig. 5. KidBus.Tracker System Architecture

Figure 6 shows the hardware prototype of KidBus.Tracker. This hardware should be installed in the school vehicle. The microprocessor used is the Arduino Mega ATmega1280. The microprocessor was used to program the RFID and GPS devices to obtain a data log of date, time, latitude, longitude and RFID tag number.

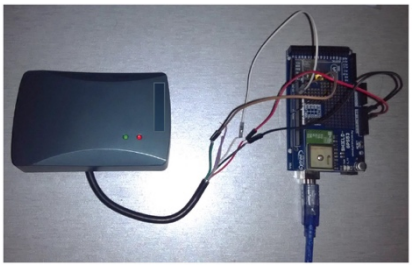

Fig. 6. KidBus.Tracker Hardware Prototype

Figure 7 shows the main modules of KidBus.Tracker. The hardware sends the data to the server for further processing. In practical sense, a GSM module needs to be installed to send the data to a web server. However, in this laboratory setting, the data are send directly to the servers via a USB cable.

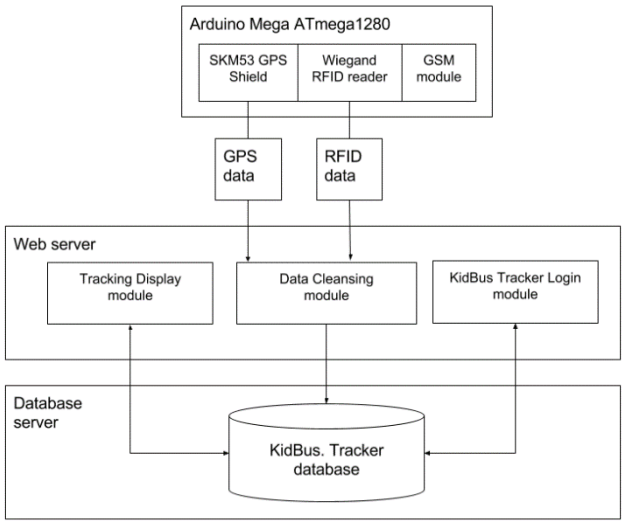

Fig. 7. KidBus.Tracker Main Modules

The RFID reader used is an off-the-shelf Wiegand RFID reader which was programmed using the Arduino Microprocessor. The main task of the GPS device is to constantly retrieve the vehicle location in real time. The device used is the SKM53 GPS Shield and the GPS data retrieved are the latitude and longitude in 6 decimal places. The GPS module has a baud rate of 9600 bits per second and relates to the transmitter Tx on digital pin 10 and the receiver Rx on digital pin 11 of the SKM53 GPS Shield board to be able to obtain GPS coordinates in test area. The GSM shield is used to transmit the data to the web server. The web server hosts the Login module, Data Cleansing module and Tracking Display module.

The Login module handles the security features of KidBus.Tracker. This includes user registration and login. The Data Cleansing module receives the raw data and process it into useful information for the end user. The cleansed data log collected from the hardware (microprocessor, RFID and GPS devices) are stored in a text file. A sample of the cleansed data log is shown in Fig. 8.

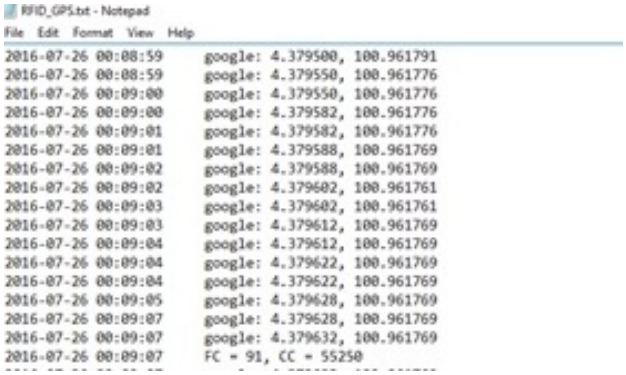

Fig. 8. Sample of KidBus.Tracker Data Log

In each line of data in the text file, the latitude, longitude, timestamps and RFID number will be extracted. These data will then be stored in the database. Figure 9 shows the database

design for KidBus.Tracker. The cleaned data log are stored in the Log table.

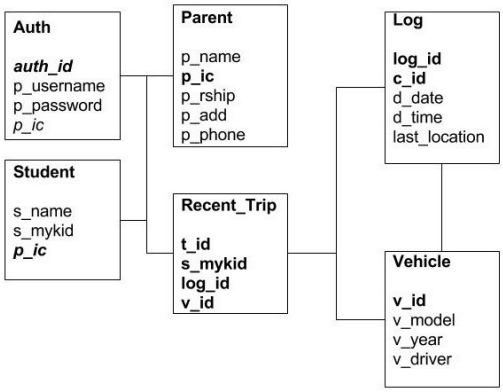

Fig. 9. KidBus.Tracker Database Design

The Tracking Display module retrieves the data from the database using PHP script and displays the information in a useful presentation on the website. The information displayed are the status of child on board the vehicle and the location of the vehicle on the location map.

D. KidBus.Tracker Website User Interface Design

KidBus.Tracker website visualizes data collected from data log and puts the data into an understandable and useful context to add value to the parents which are the user of KidBus.Tracker. When a user accesses the KidBus.Tracker website, the user will be brought to the login page as shown in Fig. 10.

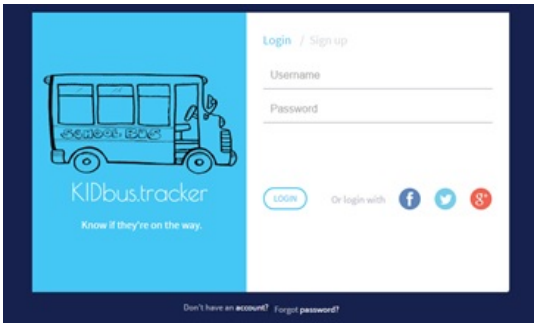

Fig. 10. KidBus.Tracker Login Page

A parent who has registered may log in to access the website. If the user has a valid identification, they will be brought to the user's homepage. The homepage displays the user's profiles such as their contact details and the user's relationship with the schoolchildren.

From the main page, the user can have access to the Children Location Tracker page, as shown in Fig. 11. On this page, users can know the status of their children's journey whether they are still on board or have alighted the vehicle. This is denoted by the icons on the most left column on the Children Trip Summary table.

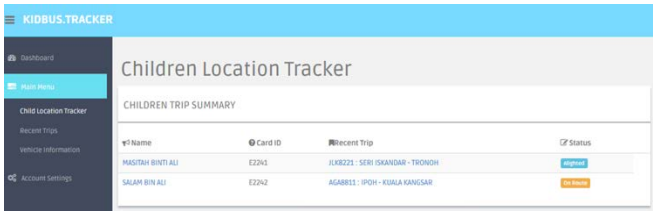

Fig. 11. Schoolchildren Location Tracker User Interface

From the Children Location Tracker page, users may view the journey of their children who are currently aboard the vehicle by pin pointing to the vehicle's current location. Users may click on their children's name to see the current location for that children on a map. The user interface for the current location is shown in Fig. 12.

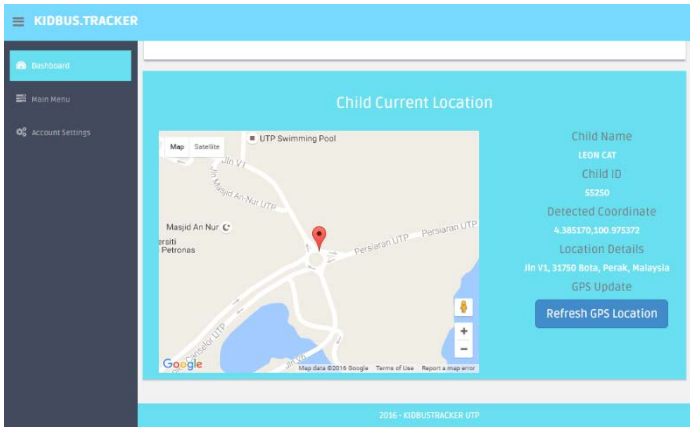

Fig. 12. Schoolchildren Current Location User Interface

In Fig. 12, the child's name, id, location details, GPS coordinates and location map showing the current location of an active journey are displayed. KidBus.Tracker website allows for live location update with through on-click request.

VII. KIDBUS.TRACKER ACCEPTANCE TEST

KidBus.Tracker was put through a brief field to test the functionality of the system in actual application. During the field test, the system was mounted on a car which was driven around a town area. During the drive, the vehicle made periodic stops to pick up and drop off passengers who tagged their RFID cards on the RFID reader. The testing was successful. An indoor test was also conducted. The test showed that the GPS device is unable to function indoors, and thus is only suitable for outdoor uses. This also indicates that the system may experience glitches in location tracking if the vehicle being tracked moves in an enclosed area such as a tunnel.

User acceptance test (UAT) was conducted to determine the acceptance of the system. Two parents were chosen as the test subjects. The parents were driven in a moving vehicle while simultaneously observing the KidBus.Tracker website. The design and performance of the system was evaluated by the parents. Qualitative data were collected from the test where the parents wrote what their opinion of the system based on the merits of layout and user interface, child tracking function, and

recommendations. Generally, both users agreed that the user interface of KidBus.Tracker has a simple but interesting design. Both users felt that tracking functions are accurate but one user suggested that there is a live update on the journey. Meanwhile, one user recommended that time that a child boarding or alighting the vehicle should be displayed at the Children Trip Summary section.

VIII. LIMITATIONS AND FUTURE WORKS

The future work on KidBus.Tracker includes the development of an administrator's interface. Schoolchildren can be registered through this administrator's interface. Currently, there are many GPS tracking system that has similar functions as KidBus.Tracker. Thus, it is crucial that value added functions to be introduced in the future to differentiate it from other GPS tracking solutions. Some of these value-added functions are the details of the vehicle and the driver, a smart notification function that could alert parents if the vehicle divert from its normal route or arrive to school late from its usual time. With these new functions, KidBus.Tracker could separate itself with other GPS tracking system. There is a need to determine an appropriate number of participants for the usability testing to ensure that KidBus.Tracker is highly accepted by the parents. KidBus.Tracker requires the involvement from school bus operators and to some extent the schools. Since the RFID reader and GPS tracker is installed in the school vehicles, it is important to get feedbacks from school vehicle operators to ascertain their level of support and acceptance of such hardware and software in their fleet vehicles.

The limitation of the work is the lack of mechanism to ensure that KidBus.Tracker is secure even when the RFID technology is used to identify the schoolchildren. In this light, the RFID tag could be lost, stolen or abused. This leads to a possibility of using biometric, for instance, to enhance the security aspects of KidBus.Tracker. Another limitation is the lack of notification to alert parents for anything unusual. Currently, KidBus.Tracker does not have a dedicated notification function to inform parents of their children's location. However, the parents can know the location of their children and the school vehicle through KidBus.Tracker website which could be viewed through a desktop or smartphones. The next version of KidBus.Tracker will see the adoption of IP messaging as the basis for its notification function.

IX. CONCLUSION

This paper presents the development of KidBus.Tracker, an identification and tracker system that allows parents to monitor their children's commute to and from school. A simple working prototype was developed to track the movement of the school vehicles using GPS, to identify the children using a passive RFID and records the timestamp of boarding and alighting the vehicle. The data logs which contain the tag id and its timestamp are sent to the server for storage and further processing. From the data log, the system can display information such as the time the child board and alight the vehicle and the journey that the vehicle has taken. Parents can view this information and the map that depicts the vehicle's journey through a website. A minimalist approach was adopted in designing the KidBus.Tracker user interface. This is accepted by the users who commented the user interface is simple and nice to look at. The tracking function is perceived to have produce accurate and depicted the correct location. As a conclusion, KidBus.Tracker provides a solution that addresses the issue of school transportation safety, thus giving the parents confidence that their children are safe when commuting to school. It is also a low-cost method for monitoring schoolchildren when they commute to school.

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